

2.4.3 Dade County

2.4.3.1 Golden Beach.

It is recommended that the Dade County, Florida, Beach Erosion Control and Hurricane Protection Project be modified to include initial restoration and periodic nourishment for the 1.2 mile shoreline located between DEP monuments R-1 and R-7 in Dade County. This project component would fill in a gap between the Dade County and Broward County authorized projects, decreasing project end losses. The optimal berm width in the analysis of this project component is 100 feet at elevation +8.2 feet NGVD and slopes of 1:10 berm to MLW and 1:30 from MLW to existing bottom. The initial project design volume is 311,000 cubic yards with a 260 foot toe of fill. The recommended renourishment interval is six years. Approximately 14.5 acres of new beach would be created under this alternative. The distance to the recommended equilibrium toe of fill, including initial fill plus advance nourishment is 832 feet with a total volume of 534,660 cubic yards. Mitigation for approximately 5.25 acres of nearshore hardground impact may be necessary in association with this project segment. One nearshore berm site has been identified as an alternative maintenance dredged material disposal site.

2.4.3.2 Sunny Isles.

The 2.65 mile beach fill project segment component located between DEP monuments R-7 and R-20 is authorized and constructed. This segment of the Dade County, Florida project is recommended for modification with an additional 20 feet optimal berm width at elevation +8.2 feet NGVD and slopes of 1:10 berm to MLW and 1:30 from MLW to existing bottom. The recommended additional design volume is 146,700 cubic yards with an additional 200 foot toe of fill extension. Approximately 6.4 acres of new beach would be created under this alternative. No hardgrounds exist in the vicinity of this project so no mitigation will be required. One nearshore berm site has been identified as an alternative maintenance dredged material disposal site.

2.4.3.3 Bakers Haulover Inlet to Government Cut.

2.4.3.3.1 Bal Harbor, Surfside, Miami Beach. The 9.3 mile beach fill project segment located between DEP monuments R-27 and R-74 is authorized and constructed. The only recommended modifications to this project segment are the addition of four nearshore berm sites that have been identified as an alternative maintenance dredged material disposal sites.

2.4.3.3.2 Government Cut. As identified in a previous design memorandum, a sand tightening of Government Cut has been recommended. This sand tightening will help reduce end losses to the southern portion of the Miami Beach project segment and further reduce Government Cut maintenance dredging requirements. The sand tightening project will be undertaken as a separate project modification.

2.4.3.4 Project Segments South of Government Cut.

2.4.3.4.1 Virginia Key/Northern Key Biscayne. Shore protection of Virginia Key and northern Key Biscayne was authorized by the River and Harbor Act of 1962

(PL 87-874). Construction of the 1.8 mile Virginia Key shoreline and 1.9 mile northern Key Biscayne shoreline was completed in 1969. The Virginia Key shoreline was renourished in 1972 and 13 groins were also constructed. This project was deauthorized in 1990. As documented in the 1992 Rehabilitation Report following Hurricane Andrew, in August 1992, the Virginia Key project was found to be performing well to date. No project segment modification is recommended for Virginia Key at this time.

2.4.3.4.2 Key Biscayne. The 2.3 mile beach fill project located between DEP monuments R-101 and R-113 was initially constructed in 1985 under the authority of Section 103 of the 1962 River and Harbor Act. Nourishment for 50 years was authorized, however, the Federal limit of \$1,000,000 under Section 103 has been met. It is recommended that the Dade County project be modified to incorporate this project segment so that Federal participation in periodic nourishment can be continued through the economic life of this project segment. An additional optimal berm width of 10 feet at elevation +8.2 feet NGVD and slopes of 1:10 berm to MLW and 1:30 from MLW to existing bottom is recommended. The additional project design volume is 106,660 cubic yards. The recommended renourishment interval is seven years. Approximately 2.8 acres of new beach would be created under this alternative.

2.4.3.5 Other Dade County Project Segments.

In addition to the above specific project segment modifications, periodic nourishment as necessary and justified is recommended for all Atlantic Ocean shorelines within Dade County for the economic life of each project segment. Dune grassing, as necessary and justified is also recommended for the Dade County shoreline as a cost effective project feature.

2.5 Comparative Impact of Alternatives

Impacts projected under the proposed action and the no-action alternatives are displayed in the following presentation matrix, Table 2.4. Details on impacts and mitigation can be found in the corresponding sections of the report.

2.6 Mitigation Summary and Plan

Table 2.4 displays projected mitigation needs for the implementation of the recommended plan. Under the recommended plan, ameliorative and mitigative measures would be required for: (1) impacts to sea turtles associated with nourishment activities; (2) impacts to sea turtles, manatees, and right whales associated with dredge operations; (3) impacts to seagrass patches associated with both the borrow operations and nourishment operations; (4) impacts to hardgrounds buried or damaged by increased sedimentation or turbidity in association with nourishment operations; and (5) impacts to hardgrounds damaged by increased sedimentation, turbidity, or mechanical damage at borrow sites. Details of mitigation measures can be found in the associated mitigation section by resource; however, no project-specific details are discussed in this report. Project-specific mitigation details and plans will be developed as project details become available and will be included in tiered documentation at a latter date.

Table 2.4 Comparative Impact of Alternatives

Significant Resources	No-Action Impacts	Net Impacts of Proposed Combination of Alternatives (Recommended Plan)	Mitigation for Proposed Combination of Alternatives (Recommended Plan)
Physical Setting	Aesthetic impacts associated with unabated beach erosion; landward advancement of surf zone.	Temporary aesthetic impacts associated with construction activities; insignificant changes in wave climate associated with borrow operations. Exhaust emissions from construction activities would add temporary and insignificant levels of pollutant to the local air sheds.	None.
Geology/Hydrology	Assumed no turbidity impacts to water quality; continual but insignificant occurrences of saltwater intrusion.	Temporary increases in turbidity adjacent to both the borrow sites and the nourishment zones, with lower turbidity associated with hopper dredging; Use of Bahamian sand would change beach color, density, and texture but have no significant impacts to either Bahamian borrow areas of potential nourishment areas in Broward and Dade counties; potential for fuel or other effluent spills from dredge-associated equipment.	None.
Endangered Species	Sea turtle nesting areas would continue to decrease in area as beaches erode; continual erosion into the dune areas during storm events may threaten endangered dune species.	Sea turtle nesting areas would increase in area with nourishment activities (100 additional acres in Palm Beach County, 91 additional acres in Broward County, and 24 additional acres in Dade County); potential for incidental "takes" of sea turtles from sand deposition, over-compaction of nonlabeled beaches, unnatural escarpments, and equipment lighting, and dredge operations; use of Bahamian sand for nourishment activities may affect the gender of hatchlings; likely encounters with the West Indian Manatee with support boats for dredge operations; possible but insignificant impacts to endangered dune species from increased tourism associated with beach nourishment; possible but unknown impact to Johnson's seagrass from borrow operations; possible but unlikely encounters with the right whale from dredge operations.	Although project-specific mitigation plans will be developed at a later date in tiered documentation, general mitigation actions are discussed herein. Nourishment Areas: Activities would be conducted outside peak sea turtle nesting season and totally outside of the nesting season in some areas of high density nesting; 65 day pre-construction nest survey and relocation conducted between sunrise and 10:00 A.M.; nourished beaches would be monitored for the 500 CPU and filled to 36 inches; escarpments greater than 18 inches and 100 feet long would be leveled; lighting on equipment would be screened/shielded and otherwise minimized and restricted to low-pressure sodium lights. Borrow Areas/Dredging: Should hopper dredging be utilized, a rigid draghead deflector would be used, inflow and outflow screening would be required, shipboard observers for both sea turtle and whale identification would be required, and the policy of dredge pumps remaining disengaged when dragheads are not firmly on bottom would be observed. Generally, with all dredge operations, whale observers would be used, as appropriate, signs would be posted on crew vessels and work stations informing the crew of possible whale and manatee encounters; no-wake speeds would be observed at all times in shallow waters; and logs of encounters for all species would be kept for the USFWS or NMFS. In areas where Johnson's seagrass may be impacted by dredging operations consultation with NMFS would occur on a case-by-case basis.
Sea Grass Beds	No effects anticipated.	Potential for burial, sedimentation, and turbidity impacts from nourishment activities to seagrass beds located adjacent to Key Biscayne; potential for temporary and insignificant impacts associated with lower light penetration caused by increased turbidity from borrow operations.	Although project-specific mitigation plans will be developed at a later date in tiered documentation, general mitigation actions are discussed herein. Should the burial or destruction of seagrass patches be unavoidable, consultation with the USFWS and NMFS should be completed to determine an appropriate mitigation plan. Should transplanting be involved in the mitigation plan, it should be completed in accordance to Fontica (1993) unless otherwise specified.

Table 2.4 (cont'd) Comparative Impact of Alternatives

Significant Resources	No-Action Impacts	Net Impacts of Proposed Combination of Alternatives (Recommended Plan)	Mitigation for Proposed Combination of Alternatives (Recommended Plan)
Hardgrounds	Additional nearshore hardgrounds would become exposed.	Burial of approximately 31 acres of nearshore hardgrounds in Palm Beach County, 25 acres of nearshore hardgrounds in Broward County, and 5 acres of nearshore hardgrounds in Dade County; potential for mechanical damage to hardgrounds adjacent to borrow operations, with higher probability associated with hopper dredges. Potential for temporary turbidity and sedimentation impacts around borrow operations.	Although project-specific mitigation plans will be developed at a later date in tiered documentation, general mitigation actions are discussed herein. Mitigation will probably be conducted post-project (no sooner than one year and within two years of project completion) due to the complexities of predicting hardground impacts and to allow the beach to come to equilibrium. Estimates of hardground impacts would be time-averaged to determine actual permanent impact; mitigation of hardgrounds will be accomplished with either limestone boulders, artificial reef modules of concrete and limestone, or concrete rip-rap. Specifics of mitigation plans (type, location, and ratio of mitigation) will be prepared as project details become available and will be included in tiered documentation.
Softgrounds	No effects anticipated.	Likely major but temporary and naturally recoverable infaunal diversity changes in some nearshore and offshore softbottom areas associated with borrow operations. Effects of borrow operations in Bahamian sand areas is inconclusive but likely similar to that expected in borrow areas in waters off Florida's coast.	None.
Inlet Communities	No effects anticipated.	Although maintenance dredging would occur in all inlets, sand transfer plants would only be constructed on the Lake Worth and South Lake Worth Inlets. Mobile species inhabiting these inlet areas that are sensitive to this perturbation would relocate to other areas during construction activities and not be significantly affected. Turbidity, sedimentation, and lower light penetration impacts to hardground communities and sea grass beds would likely be minor because of low silt content of material in this area.	None.
Dune Communities	Continual landward migration of surf zone may threaten dunes during storm events.	Approximately 100, 91, and 24 acres of new beach would be created in Palm Beach, Broward and Dade counties, respectively; increased density of some existing grass species should be realized with dune-grazing activities in areas for which this is planned. Increased shore width would better protect dunes and their communities during storm activities.	None.
Migratory Birds	No anticipated effects.	Migratory birds may be temporarily discouraged from using areas during construction activities and would relocate to other areas away from anthropogenic activity.	None.
Socioeconomic Resources	Approximately \$33 million in storm damages associated with 10 to 20 year storm could be experienced in Region III; decline of commerce associated with beach tourism; potentially small increases in diving opportunities associated with increased hardground exposure.	Short-term employment effects for regional labor would have direct and indirect benefits on the local economies. Approximately \$33 million storm damages associated with the 10 to 20 year storm would be avoided in Region III with the implementation of the recommended plan.	None.
Cultural Resources	No anticipated effects.	Potential disturbance of undocumented submerged archaeological sites.	Although project-specific mitigation plans will be developed at a later date in tiered documentation, general mitigation actions are discussed herein. Consultation with SHPO upon any positive magnetometer surveys at offshore borrow areas and sand bypass systems at inlets. Significant magnetometer anomalies will be avoided with the use of buffer zones or investigated by archaeological divers prior to disturbance should the sites be unavoidable.

Table 2.4 (cont'd) Comparative Impact of Alternatives

Significant Resources	No-Action Impacts	Net Impacts of Proposed Combination of Alternatives (Recommended Plan)	Mitigation for Proposed Combination of Alternatives (Recommended Plan)
Recreational Resources	Continued shoreline recession with corresponding decreases of beach area; likely increases of hardground diving areas in nearshore environment.	Estimated 100, 91, and 24 acres of new beach would be created in Palm Beach, Broward, and Dade counties, respectively; temporary aesthetic impact of nourishment activities, equipment, and crews would deter beach activities in the area during construction. Temporary increases in turbidity may degrade snorkeling and diving experiences around borrow and nourishment areas.	None.
Other Considerations	Energy requirements associated with clean-up after storm events would continue to increase concurrent with realized damages.	Two parcels near Davis Beach are listed as undeveloped coastal barriers as defined by the Coastal Barrier Resources Act, which require coordination with USFWS prior to nourishment activities. Insignificant energy requirements for construction and for the permanent operation of the sand transfer plant would also be required.	Coordination with USFWS must be accomplished for any nourishment activities on the two parcels listed on the Coastal Barrier Resources System.

Note: Mitigation refers to actions required to ameliorate potential impacts and mitigate absolute impacts caused by the implementation of the recommended plan of COFS.

3.0 AFFECTED ENVIRONMENT

3.1 Physical Setting

3.1.1 Climate

There are two U.S. Weather Bureau offices within Region III, which are located at the West Palm Beach and Miami airports. The National Oceanic and Atmospheric Administration provides a Local Climatic Annual Summary with Comparative Data for each location. Wind data for each location is discussed in the following paragraphs. Although completely within the temperate zone, southeastern Florida has generally a subtropical climate due to the proximity of the Florida current or Gulf Stream. Annual precipitation averages approximately 60 inches per year in West Palm Beach and 55 inches per year in Miami. The mean daily maximum temperature in West Palm Beach and Miami is approximately 82° Fahrenheit (F). The mean daily minimum temperature is slightly cooler in West Palm Beach at 67°F, 2°F cooler than Miami.

3.1.2 Storm Events

The shoreline of the study area is open to wave attack from the north-northeast through east to the southeast. Normally, the wave climate from these directions is modest in intensity. However, the preponderance of beach erosion and generally all of the storms emanating from the northeast direction are from cyclonic disturbances. The major threats to the stability of the shoreline in the study area are surges and waves caused by tropical storms (including hurricanes) and northeasters. Since 1960, Palm Beach and Broward counties have had three hurricanes and three tropical storms each, and Dade County has had three hurricanes and two tropical storms. For a detailed discussion of tropical and northeaster storm development and of past storm activity, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.3 Winds

Local winds are the primary generating mechanism of the short-period waves experienced in the project area. These winds vary in direction, intensity, duration, and seasonality. There are marked differences between winter and summer wind conditions in the study area.

Prevailing, or most common, winds are from the northeast through the southeast and average 9.7 and 9.3 mph for West Palm Beach and Miami, respectively. During the fall and winter months, winds are often out of the northwest through the northeast as a result of cold fronts with their associated areas of low pressure, which generally traverse the continental U.S. from west to east. The summer months are characterized by tropical weather systems traveling east to west in the lower latitudes. The fastest wind speed of 86 mph observed for one minute and the peak gust of 115 mph for Miami, Florida, both occurred during Hurricane Andrew in August 1992. These values represent wind speeds experienced during Hurricane Andrew. For a detailed discussion of winds in Region III, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.4 Waves

The principle cause of beach erosion is the action of waves that break on a beach, resulting in sediment transport. Waves cause littoral movement in the longshore direction as well as the onshore-offshore direction. Due to the general north-south bearing of the Region III coastline, waves approaching from the north and northeast cause a southerly sand movement, and waves from the south and southeast cause a northerly movement. Waves from the east create very little alongshore sand movement. The east coast of Florida experiences seasonal reversals in the direction of littoral drift (south in winter and north in summer) due to seasonal changes in wind and, thus, wave direction.

The waves that occur in the vicinity of the study area consist of "sea" and "swell." Local seas are the product of local winds associated with both mild and severe weather events and are dependent on wind speed, fetch, and water depth. These parameters also dictate the wave height and period that will be generated. Seas are generally quite steep (having a large wave height to wavelength ratio) and can be random due to superposition of waves from a number of different directions.

Swells, unlike seas, are comprised of waves that have been generated from distant storms or open ocean prevailing winds and are no longer under the influence of local winds. These waves generally have longer periods, and thus longer wavelengths, than wind waves. Northeasters and hurricanes often generate swells that impact the coast of south Florida. The Little Bahama Bank to the northeast and east, the Great Bahama Bank to the southeast and east and the island of Cuba to the south complicate the interpretation of swell data in Region III. The fetch to the east is limited to about 60 miles by the presence of the Bahama banks, decreasing the chance of receiving major swells. The main directions of approaching swells along this part of the coast are from the northeast and southeast. Large waves produced over a long fetch by storms in the north Atlantic can reach the project area even though this approach window is quite narrow. In contrast, the fetch to the south and southeast is limited to about 200 miles, resulting in smaller waves for similar wave generating parameters. Therefore, the predominant wave energy sources in the study area are wind-generated waves or local seas. For a detailed discussion of wave action in Region III, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.5 Currents

The dominant currents in the study area are the Florida Current (the portion of the Gulf Stream flowing through the Florida Straits), longshore current, and tidal currents through inlets. The most significant is the Florida current of the Florida Gulf Stream, which flows approximately one mile offshore, along most of Region III's coastline. With the exception of intermittent local reversals, its flow is northward between 17 and 37 miles per day. Longshore currents are generally southward in the winter and northward in the summer. Velocities as high as 7.5 feet per second have been recorded for longshore currents in Region III (Lake Worth Pier), but typically, currents are approximately 1.0 foot per second (*Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District). Tidal flood currents (landward) and ebb currents (seaward) also affect the morphology of the coast. Peak tidal current velocities of 6.0 feet per second have been documented at South Lake Worth Inlet, with Government Cut Inlet having a slightly lower average tidal peak velocity of

approximately 5.5 feet per second. For a more detailed discussion of currents in Region III, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.6 Tides

Tides are important factors in littoral processes. The tide level influences the water depth, which dictates the point at which a wave approaching shore will break. The tide level gradient and phase also directly affects current speeds within inlets. Astronomical and storm tides are the two basic tide types that occur in the ocean near the study area. Theoretical astronomical tides in the study area are predictable; however, non-astronomical tides and the still-water levels or storm tides (storm surges) caused by extremely high wind velocities coupled with very low barometric pressures (during tropical depressions and storms or hurricane conditions) are not predictable. Astronomical tides in the study area are semidiurnal; that is, there are two high and two low waters each lunar day (24.84 hours). Highest tides occur at spring tide (full moon and new moon) conditions and in association with storms as a combination of wind setup, barometric pressure setup, and normal peak tides. Extremely high wind velocities coupled with very low barometric pressures during tropical depressions and storms or hurricane conditions have caused tides as high as 10.6 feet above MLW on the south Dade County shoreline. For a detailed discussion of tides in Region III, see *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.7 Storm Surge

The rise of the ocean surface above its normal high-tide level during a storm is referred to as the storm surge, or still-water, elevation. With a higher still-water level (surge), larger waves can reach the shoreline, accelerating erosion. The increased water level elevation is due to a variety of factors, including waves, wind shear stress, and atmospheric pressure. An estimate of water level change is essential for the design of shore protection projects since an increase in water level will allow larger breakers to attack the shoreline at higher elevations above mean sea level.

The storm surge along the Key Biscayne ocean shoreline caused by Hurricane Andrew in August 1992 was reported to be 10.1 and 10.6 feet above MLW along the northern and southern ends of Key Biscayne, respectively. Key Biscayne was completely inundated during Andrew. These storm surges, which undoubtedly included wave runup, were obtained by the measurement of high-water marks on structures along the shoreline by the Coastal Engineering Research Center (CERC), the Florida Department of Natural Resources (FDNR), and the U.S. Geological Survey (USGS). The highest elevation of the sea surface measured in Palm Beach County was 11.2 feet, which occurred during the hurricane of September 1928.

The Federal Emergency Management Agency (FEMA) has performed investigations to determine hurricane surge elevation in the Flood Insurance Studies (FIS) for Palm Beach, Broward, and Dade counties. The maximum calculated wave heights for the 100-year still water elevation at the Region III Atlantic Ocean shoreline in Palm Beach, Broward, and Dade counties are 11 feet, 12 feet, and 14 feet, respectively.

3.1.8 Sea Level Rise

Eustatic sea level change is defined as a global change of oceanic water level. Total relative sea level change is the difference between the eustatic sea level and any change in local land elevation. Throughout geologic history, global sea level variations, both rise and fall, have occurred. Some authorities have found evidence to indicate that we may be entering a new ice age with a resultant sea level drop. Others argue that increasing atmospheric concentrations of carbon dioxide and other gases are causing the earth to warm, contributing to a sea level rise. Both global cooling or warming thus contribute to absolute global sea level change.

There has been a steady decline in the predicted rise in sea level from two meters in 1983 to 0.5 meters in 1990. The uncertainty in each estimate initially declined as scientists thought they increasingly understood the relationship between global warming and sea level rise. However, the uncertainty of the most recent NRC estimate in 1990 is greater than any since the original 1983 EPA study. The 1990 NRC estimate predicts a 0.5-meter rise in sea level by the year 2100 with an error of plus or minus one meter. The lower limit of this NRC prediction is a sea level fall of 0.5 meters (Houston, 1993). For a detailed discussion of eustatic and local sea level rise in Region III, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.1.9 Air Quality and Noise

Ambient air quality in the three counties is generally good because of prevalent ocean breezes from the northeast through the southeast. Palm Beach, Broward, and Dade counties are in attainment with the Florida State Air Quality Implementation Plan for all parameters but ozone. For ozone, the three counties are in moderate non-attainment.

Ambient noise around the project area is typical to that experienced in recreational environments and ranges from low to moderate based on the density of development and recreational usage. Major noise producers include breaking surf, beach and nearshore water activities, adjacent commercial and residential areas, and boat and vehicular traffic.

3.2 Geology

3.2.1 Geology and Geomorphology of Study Area

The Florida Plateau, occupied by present-day Peninsular Florida, had its origins during the Mesozoic Era, some 200 million years before the present. The plateau has been alternately dry land or covered by shallow seas since that time, with an accumulation of 4,000 to 20,000 feet of carbonate and marine sediments over that period. During the Pleistocene Epoch, Florida experienced four periods of inundation and emergence, and this resulted in the deposition of four surficial Pleistocene formations: the Miami (youngest), Key Largo, Anastasia, and Fort Thompson (oldest). During the last glacial retreat (Wisconsin glaciation) a thin sheet of quartzose sand, the Pamlico Sand, was deposited over the Miami and Anastasia formations. The present day barrier islands of southeast Florida were formed during the Holocene (Recent) Epoch, within the last 7,000 to 6,000 years. The sand comprising the modern barrier islands of Region III is partially quartz sand that has migrated southward along the coast from rivers and the coast north of Region III and from the reworking of Pamlico Sand that blankets the region.

In Palm Beach County, the barrier islands are founded on the Anastasia Formation, and in Broward and Dade counties the barrier islands are founded on the Miami Limestone. For a detailed discussion of regional and area geology, see the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996*, USACE, Jacksonville District.

3.2.2 Water Quality

Groundwater, the major source of potable water in Region III, is supplied by two major aquifers: the Biscayne or surficial aquifer and the Floridan aquifer. The Biscayne or surficial aquifer is an unconfined sand and shell aquifer extending from 30 feet deep in the western reaches of Region III to between 300 and 400 feet deep at the coast. The Floridan aquifer lies between 700 and 1,100 feet deep and is confined by an approximately 400-foot layer of marine clay. Because of salinity and the cost of reverse osmosis treatment, this aquifer is generally not used for potable uses; however, potable use is increasing as Biscayne or surficial reserves become optimized. Water quality in the Biscayne or surficial aquifer is generally good, but salinity is a problem in transition areas along the margin of the freshwater/saltwater interface. Saltwater intrusion from canal construction and heavy withdrawals has been an historic problem with groundwater salinity in Region III, but with the advent of salinity control structures and water management policies, salinity has decreased in most areas of concern. Salinity is largely controlled by recharge precipitation. Connate water, or relic seawater, is also a problem in the inland wells. Connate water encounters are more likely the further west and the deeper the withdrawals in Region III.

Waters off the coast of Palm Beach, Broward, and Dade counties are classified as Class III waters by the State of Florida. Class III category waters are suitable for recreation and the propagation of fish and wildlife. Turbidity is the major limiting factor in coastal water quality in Region III. Turbidity is measured in Nephelometric Turbidity Units (NTU), which quantitatively measure light-scattering characteristics of the water. However, this measurement does not address the characteristics of the suspended material that creates turbid conditions. According to Dompe and Haynes (1993), the two major sources of turbidity in coastal areas are very fine organic particulate matter and sediments and sand-sized sediments that become resuspended around the seabed from local waves and currents. Florida state guidelines set to minimize turbidity impacts from beach restoration activities confine turbidity values to under 29 NTU above ambient levels outside the turbidity mixing zone for Class III waters.

Ambient turbidity data for Region III coastal waters are largely non-existent except for several areas around Region III's inlets. However, turbidity values are generally lowest in the summer months and highest in the winter months, corresponding with winter storm events and the rainy season (Dompe and Haynes, 1993; Coastal Planning & Engineering [CPE], 1989). Moreover, higher turbidity levels can generally be expected around inlet areas, and especially in estuarine areas, where nutrient and entrained sediment levels are higher. Although some colloidal material will remain suspended in the water column upon disturbance, high turbidity episodes usually return to background conditions within several days to several weeks, depending on the duration of the perturbation (storm event or other) and on the amount of suspended fines.¹

¹For instance, after average, baseline wave and current conditions are reestablished, it would generally take approximately 72 hours for fines ranging in size 5-9 to settle to the bottom (Fisher, 1994).

3.2.3 Sand Source Location

3.2.3.1 Existing Borrow Area Locations

Palm Beach County: There are four established borrow areas within Palm Beach County: (1) an ebb tidal shoal at Jupiter Inlet; (2) an offshore area at Ocean Ridge; (3) an offshore area at Delray Beach; and (4) an area off Boca Raton.

Broward County: Most of the sand in the established construction borrow areas has already been used for beach nourishment.

Dade County: After the next beach renourishment, all available beach quality offshore sand sources will have been exhausted.

3.2.3.2 Potential Future Borrow Area Locations.

Palm Beach County: Geophysical surveys indicate a potential sand source running the entire length of the county between the two offshore reefs. For estimation purposes, potential borrow area boundaries were kept a minimum of 2,000 feet from shore to insure a water depth of greater than 20 feet. Estimated quantities of available sand borrow are: (1) Jupiter Inlet Colony - 70,000,000 cubic yards; (2) Jupiter Inlet to Riviera Beach (DEP monuments R-12 to R-50) - 274,827,611 cubic yards; (3) Lake Worth Inlet to Manalapan (DEP monuments R-75 to R-130) - 186,713,585 cubic yards; (4) South Lake Worth Inlet to Boca Raton Inlet (DEP monuments R-151 to R-222) - 123,480,486 cubic yards; and (5) DEP monument R-222 to the Broward/Dade County line - 11,765,124 cubic yards. The total estimated quantity of available offshore sand in Palm Beach County is 655,025,947 cubic yards. This quantity of sand is more than enough to satisfy existing renourishment needs of 26,253,000 cubic yards for Palm Beach County.

Broward County: Using the maps produced from the geographic information system (GIS), all available hardground areas were delineated and have been buffered by a distance of 400 feet. Most of the borrow areas have been delineated by geophysical surveys, with few having core borings. Since these areas are in the same situation as all other borrow areas in Dade and Broward counties, it is reasonable to assume that most of the sand is of similar quality and suitable for beach nourishment. Estimated quantities of available sand borrow are: (1) Deerfield Beach to Hillsboro Inlet (DEP monument R-1 to R-24) - 10,518,180 cubic yards; (2) Pompano Beach to Fort Lauderdale (DEP monuments R-24 to R-85) - 16,763,630 cubic yards; and (3) Dania to Hallandale (DEP monuments R-100 to R-128) - 1,376,379 cubic yards. The total estimated quantity of available offshore sand in Broward County is 28,658,188 cubic yards. This quantity represents 73 percent of the needed 39,243,000 cubic yards of sand for existing planned renourishment projects for Broward County.

Dade County: Two potential borrow areas have been identified: (1) an area located eight miles north of Miami Beach with an estimated 1,500,000 cubic yards of available sand; and (2) an area located 16 miles south of Miami Beach with an estimated 2,000,000 cubic yards of available sand. Total project requirements for Dade County are 11,936,000

cubic yards of sand, over five times the available potential borrow quantities. Future renourishment projects in Dade County will require alternate sand sources.

3.2.3.3 Alternate Sand Source Locations

Upland Sources: Offshore sand sources are plentiful in Palm Beach County. However, to the south in Broward County, the quantity of beach quality sand decreases, and in Dade County there are virtually no remaining sand reserves once the next renourishment is completed. Test results on native beach materials and sands available from commercial upland sand quarries indicate that, in most cases, the upland sand sources are texturally very compatible with little or no overfill required. The upland quarries are located on the Lake Wales Ridge of the Central Highlands physiographic region of south Florida. One upland source area is located southwest of Lake Okeechobee, at Ortona, Florida. There are presently two quarries at Ortona, and both have barge canal access to the Okeechobee Waterway.

Bahamian Sand: A second alternate sand source is Bahamian sand. Comprised of 14 major carbonate banks, the Bahamians have a virtually endless supply of nourishment sand for Region III's coastline (CPE, 1994; Hine and Neumann, 1977 [as cited by CPE, 1994]). Leases to dredge 40-75 billion cubic yards of Bahamian sand have already been granted to Marcona Ocean Industries (Miller-Way, *et al.*, 1987; Slatton, 1986 [both cited by CPE, 1994]). Areas outside of the Marcona lease where significant Bahamian sand deposits can be found include the Southern Tongue of the Ocean, Jolten's Keys, the Eleuthera Keys, and Little Bahama Bank. Bahamian sand is currently used as an essential ingredient for Portland glass and cement, filtration media, and agricultural lime, flue gas desulfurization, fine aggregate, and as an additive for poultry and animal feed (Slatton, 1986 [as cited by CPE, 1994]).

3.2.4 Sand Quality

The sand occurring on the beaches and offshore in Palm Beach County is predominantly quartz sand that was carried down to the sea by the Savannah, Altamaha, and other rivers of Georgia and the Carolinas and then driven southward by shore currents and wave action. This sand is coarser near shore, becoming finer with distance offshore. Sand south of Palm Beach County is predominantly carbonate material from disintegrated shells.

3.2.4.1 Native Beach Sand Quality

Palm Beach County: Native beach sands are predominantly quartz, generally well sorted and free from appreciable amounts of deleterious fines (material passing a U.S. No. 200 sieve). In Palm Beach County, the mean grain size ranges from 0.43 millimeter (mm) in the northern portion of the county near Jupiter Inlet to 0.31 mm near Boca Raton Inlet. Silt content (material finer than the No. 200 sieve) is usually less than three percent. Visual estimates of shell content range from one percent to 75 percent, with a composite mean value of 50 percent by weight.

Broward County: The beach sands of Broward County are predominantly carbonate grains and shell fragments with small amounts of quartz grains. Mean grain sizes range from 0.48 mm at Lauderdale-by-the Sea to 0.36 mm at Hollywood in south Broward.

Dade County: As in Broward County, the beach sands of Dade County are predominantly carbonate grains and shell fragments with minor amounts of quartz grains. Mean grain sizes range from 0.36 mm at Miami Beach to 0.29 at Key Biscayne.

3.2.4.2 Potential Borrow Source Quality

From West Palm Beach to the Florida Keys, there are generally three separate series of reefs or hardbottoms located offshore. Generally, there is a sand and rubble zone between the first and second hardbottom areas and more abundant sand pockets between the second and third hardbottom areas. These two zones provide the potential sand resources for beach nourishment.

Palm Beach County: The Jupiter Inlet ebb shoal is proposed as the borrow area for the Jupiter/Carlin project. The mean grain size of the primary borrow area material is 0.38 mm. Offshore borrow areas generally have smaller grain size sands than nearshore sources. The offshore sands in north Palm Beach County have a mean grain size of 0.38 to 0.43 mm and a silt content of around five percent. The offshore sands in south Palm Beach County have a mean grain size of 0.24 to 0.37 mm and a silt content of less than five percent.

Broward County: Potential offshore borrow areas in north Broward County have a mean grain size of 0.30 mm and mean silt content of 9.4 percent, and the borrow areas in south Broward County have mean grain sizes ranging from 0.34 mm to 0.51 mm and mean silt content of 6.5 percent.

Dade County: The potential offshore borrow source near Miami Beach has a mean grain size of 0.31 mm. Test results from a geotechnical study performed in 1978 and 1979 indicate that there was less than five percent material passing a U.S. 200 sieve (silt).

3.2.4.3 Alternate Sand Source Quality

Upland Sources: The quartz sands available from the Ortona, Florida, area southwest of Lake Okeechobee have a mean grain size range of 0.48 mm to 0.55 mm. Silt content is usually less than five percent.

Bahamian Sand: Bahamian sand is typically a bright white carbonate sand found in natural deposits on the Bahama banks. These deposits contain only traces of silt or clay-sized material. The mean grain size is 0.29 mm. The specific gravity of oolitic sand ranges from 2.75 to 2.88, compared to 2.65 for quartz sand. The more dense Bahamian sand behaves hydraulically like larger sized quartz grains. Bahamian sand's higher sphericity, higher specific gravity, and well-rounded texture cause it to have a hydraulic equivalent mean grain size of 0.34 mm.

3.2.5. Hazardous, Toxic, and Radioactive Waste

No hazardous, toxic, or radioactive waste sites are located in the affected environment of COFS action alternatives, nor are there currently any hazardous, toxic, and radioactive waste producers located adjacent or that discharge effluents near any COFS project site.

3.3 Biological Resources

3.3.1 Endangered Species

3.3.1.1 Sea Turtles. Sea turtles are present in the open ocean for much of the year in Region III because of the warm water temperatures and rock habitat used for both foraging and shelter. The predominant species of marine turtles is the loggerhead sea turtle, *Caretta caretta*, although green turtles, *Chelonia mydas*; leatherbacks, *Dermochelys coriacea*; Kemp's ridley, *Lepidochelys kempii*; and hawksbills, *Eretmochelys imbricata* are also known to exist in the area.

Having the highest average density of sea turtle nests within Region III, Palm Beach County reported a total of 15,013 nests in 1992 over its 34.3-mile survey length, which is 76 percent of its 45 mile shoreline (County of Palm Beach, 1994a). Of this total, 14,357 (95.6 percent) nests were loggerhead sea turtles, 552 (3.7 percent) were green turtles, and 104 (0.7 percent) were leatherbacks. According to the Florida DEP, the endangered hawksbill sea turtle has also been known to nest in the area on an infrequent basis. The Florida DEP considers the nesting season for all species to be 1 March through 31 October (for Palm Beach and Broward counties). Palm Beach County currently relocates only one to two percent of its identified nests to areas of less intense recreational activity and potential disturbance.

Broward County nesting density is less than that in Palm Beach. Overall, 2,221 nests were recorded in 1992 over its 24-mile beach (100 percent survey) (County of Broward, 1993). For all intents and purposes, 100 percent of the recorded nests were loggerheads, although greens, leatherbacks, and hawksbills have been known to nest in the area and some green and leatherback nests were recorded. Beaches listed by decreasing nesting densities are Hillsboro, Pompano, Lloyd Park, Fort Lauderdale, and Hollywood-Hallandale. As with Palm Beach County, the nesting season for all species is between 1 March and 31 October.

Dade County nesting densities are much lower than those of Palm Beach and Broward counties. All of the 21-mile shoreline in Dade County is surveyed for nesting activity, and all nests except from the areas around Golden Beach and Bill Baggs Cape are relocated to a central hatchery on Miami Beach. As either Palm Beach and Broward counties, Dade County nests are predominantly loggerhead; however, greens, leatherbacks, and hawksbills do nest on occasion. In 1992, 200 nests were recorded, of which only one or two percent were greens. Nesting densities south of Government Cut have been documented to be significantly higher than those north of the Cut (Flynn, 1992). The nesting season for the southern Florida area of Dade County is between 1 May and 31 October.

3.3.1.2 West Indian Manatees. Although the estuarine waters around Region III's inlets provide year-round habitat for the West Indian manatee, *Trichechus manatus*, they travel southward in the winter, resulting in a larger winter transient population than during other times

of the year. Although the West Indian manatees have been observed in the open ocean, they feed and reside mainly in the estuarine areas and around inlets. A letter from the Florida DEP dated 14 November 1994 indicates that no significant foraging habitat is known to be located in the areas around project sites in Region III, nor have West Indian manatees been known to congregate in the nearshore environments around project sites in Region III.

3.3.1.3 Other Endangered Species. Rare, threatened, and endangered species likely to be encountered along the study areas of Palm Beach, Broward, and Dade counties are listed in Table 3.1. The species that would most likely be impacted by COFS actions are sea turtles and manatees (detailed discussions above).

3.3.2 Sea Grass Beds

Since sea grass is dependent on light penetration for photosynthesis, sea grass beds are found mainly in shallow areas and in areas that maintain clear waters by tidal flushing around inlets (County of Palm Beach, March 1992). Based on maps of existing sea grass beds provided by the FMRI (1994h), there are no sea grass beds offshore or in the immediate vicinity of the inlets; however, there are significant, dense beds east of Key Biscayne and northern Virginia Key. The dominant species of sea grass in decreasing general order of abundance are shoal grass, *Halodule wrightii*; turtle grass, *Thalassia testudinum*; manatee grass, *Syringodium filiforme*, *Halophila decipiens*, *Halophila johnsonii*, and *Halophil engelmanni*. Macro-algal species found among sea grass beds include *Caulerpa* species (*C. sertularioides*, *C. prolifera*, and *C. mexicana*), *Udotea* sp., *Penicillus* sp., *Halimeda* sp., *Dictyota* sp., *Padina* sp., *Hypnea* sp., and *Anthophora spicifera*. Specifically, *Halodule*, *Syringodium*, and *Thalassia* have been observed in order of decreasing densities in the vicinity of Key Biscayne (Flynn *et al.*, 1991).

3.3.3 Nearshore Communities

3.3.3.1 Soft Bottom. The beaches of southeast Florida are exposed beaches and receive the full impact of wind and wave action. Intertidal beaches usually have low species richness, but the species that can survive in this high energy environment are abundant. The upper portion of the beach, or subterrestrial fringe, is dominated by various talitrid amphipods and the ghost crab *Ocypode quadrata*. In the midlittoral zone (beach face of the foreshore), polychaetes, isopods, and haustoriid amphipods become dominant forms. In the swash or surf zone, beach fauna is typically dominated by coquina clams of the genus *Donax*, the mole crab *Emerita talpoida*. All these invertebrates are highly specialized for life in this type of environment (Spring, 1981; Nelson, 1985; and U.S. Fish and Wildlife Service [USFWS], 1990).

Shallow subtidal soft bottom habitats (0 to 1 meters [0 to 3 feet] depth) show an increasing species richness and are dominated by a relatively even mix of polychaetes (primarily spionids), gastropods (*Oliva* sp., *Terebra* sp.), portunid crabs (*Arenaeus* sp., *Callinectes* sp., *Ovalipes* sp.), and burrowing shrimp (*Callinassa* sp.). In slightly deeper water (1 to 3 meters [3 to 10 feet] depth) the fauna is dominated by polychaetes, haustoid and other amphipod groups, bivalves such as *Donax* sp. and *Tellina* sp. (Marsh *et al.*, 1980; Goldberg *et al.*, 1985; Gorzelany and Nelson, 1987; Nelson, 1985; Dodge *et al.*, 1991). Dexter (1972), Croker (1977), and Shelton and Robertson (1981) have indicated there is no latitudinal pattern of diversity and species distribution among the tropical intertidal sand beach macrofauna.

Table 3.1. Rare, Threatened, and Endangered Species in the Coastal Study Areas of Palm Beach, Broward, and Dade Counties

Common Name	Scientific Name	Notes	Federal	Florida State
Birds				
Peregrine falcon	<i>Falco peregrinus</i>	Tr., W., C., Es	E	E
Piping plover	<i>Charadrius melodus</i>	Tr., W., C.	T	T
Least tern	<i>Sterna antillarum</i>	Tr., N., C.	T	T
Reddish egret	<i>Egretta rufescens</i>	Tr., Es	NL	T
Little blue heron	<i>Egretta caerulea</i>	Tr., N., Es	NL	SC
Snowy egret	<i>Egretta thula</i>	Tr., N., Es.	NL	SC
Tri-colored heron	<i>Egretta tricolor</i>	Tr., N., Es.	NL	SC
American oystercatcher	<i>Haematopus pallianus</i>	Tr., N., C.	NL	SC
Osprey	<i>Pandion haliaetus carolinensis</i>	Tr., C., Es.	NL	SC
Eastern brown pelican	<i>Pelecanus occidentalis</i>	Tr., N., C., Es.	NL	SC
Reptiles				
Green sea turtle	<i>Chelonia mydas</i>	Tr., N., C.	E	E
Leatherback sea turtle	<i>Dermochelys coriacea</i>	Tr., N., C.	E	E
Hawksbill sea turtle	<i>Eretmochelys imbricata</i>	Tr., C.	E	E
Kemp's Ridley sea turtle	<i>Lepidochelys kemp</i>	Tr., C.	E	E
Loggerhead sea turtle	<i>Caretta caretta caretta</i>	Tr., N., C.	T	T
Gopher tortoise	<i>Gopherus polyphemus</i>	C. (Terrestrial)	C2	NL
Fish				
Common snook	<i>Centropomus undecimalis</i>	Tr., C., Es.	NL	SC
Mammals				
Right whale	<i>Eubalaena glacialis</i>	Tr., O.	E	E
Fin whale	<i>Balaenoptera physalus</i>	Tr., O.	E	E
Sei whale	<i>Balaenoptera borealis</i>	Tr., O.	E	E
Humpback whale	<i>Megaptera novaeangliae</i>	Tr., O.	E	E
Sperm whale	<i>Physeter catodon</i>	Tr., O.	E	E
West Indian manatee	<i>Trichechus manatus</i>	Tr., C., Es.	E	E
Plants				
Beach jacquemontia	<i>Jacquemontia reclinata</i>	C.	E	E
Johnson grass	<i>Halophila johnsonii</i>	Es., C.	PT	PT
Sand-dune surge	<i>Chamaesyce cumulicola</i>	C.	C2	NL
Garbers spurge	<i>Chamaesyce garberi</i>	C.	T	E
Large-flowered rosemary	<i>Conradiana grandiflora</i>	C.	C2	E
Cupgrass	<i>Eriochloa michauxii</i> var. <i>simpsonii</i>	C.	C2	NL
Hairy beach sunflower	<i>Helianthus debilis</i> sp. <i>vestitus</i>	C.	C2	NL
Florida lantana	<i>Lantana depressa</i>	C.	C2	NL
Devil's shoestring	<i>Tephrosia angustissima</i>	C.	C2	E
Burrowing four-o'clock	<i>Okenia hypogaea</i>	C.	NL	E
Beach-star	<i>Remirea maritima</i>	C.	NL	E
Bay cedar	<i>Suriana maritima</i>	C.	NL	E
Coconut palm	<i>Cocos nucifera</i>	C.	NL	T
Beach-creeper	<i>Ernodea littoralis</i>	C.	NL	T
Sea-lavander	<i>Mallotonia gnaphalodes</i>	C.	NL	T
Inkberry	<i>Scaevola plumieri</i>	C.	NL	T
Black mangrove	<i>Avicennia germinans</i>	Es.	NL	SC
Red mangrove	<i>Rhizophora mangle</i>	Es.	NL	SC

Notes: E = Endangered T = Threatened R = Rare PE = Pending Endangered
 SC = Special Concern NL = Not Listed Tr = Transient O = Offshore
 W = Wintering N = Nesting Es = Estuarine C = Coastal
 C2 = Candidate PT = Proposed Threatened listing

Sources: County of Palm Beach, 1994b; State of Florida, DEP. 1994e; State of Florida, Florida Game and Freshwater Fish Commission, 1990 [as cited by USACE, 1985].

Surf zone fish communities are typically dominated by relatively few species (Modde and Ross, 1981; Peters and Nelson, 1987). Vare (1991) observed seven species of fish considered to live independent of reef or hard bottom outcrops in the nearshore sand bottom areas off Palm Beach County. Listed in order of their frequency (most common to least common), these were Atlantic threadfin herring, *Opisthonema oglinum*; blue runner, *Caranx crysos*; spotfin mojarra, *Eucinostomus argenteus*; southern stingray, *Dasyatis americana*; greater barracuda, *Sphyrna barracuda*; yellow jack, *Caranx bartholomaei*; and the ocean triggerfish, *Canthidermis sufflamen*, none of which are of local commercial value. Most of the fish making up the inshore surf community tend to be either small species or juveniles (Modde, 1980).

3.3.3.2 Hardgrounds. Exposed nearshore and surf zone hard bottom in Palm Beach County consists of outcrops of coquina rock that are part of the Anastasia Formation. These outcrops, commonly referred to as "beach rock," are comprised of coquina shells, sand, and calcareous limestone (Hoffmeister *et al.*, 1967). The Anastasia Formation dates from the Late Pleistocene and extends southward along Florida's east coast from St. Augustine to slightly south of Boca Raton, where it grades into the contemporaneous Miami Oolite formation (Lovejoy, 1987). The Miami Oolite Formation, outcropping in Broward and Dade counties, is composed of minute calcareous spherules or ooids formed in seawater by the precipitation of lime around microscopic particles in the water column. These precipitated particles settle to the bottom and eventually become bound together by secondary calcite to form a hard substrate (Hoffmeister *et al.*, 1967).

Where they outcrop, both these geologic formations exhibit the spur and groove characteristics of reefs formed in areas exposed to wave action (Shinn, 1988). Although they outcrop only intermittently, both formations are contiguous beneath the beach zone. Only their higher profile areas are exposed by wave action and become available as hard bottom or beach rock habitats (Duane and Meisburger, 1969). Beach rock outcrops are typically located in 0 to 3 meters (0 to 10 feet) of water and are physically stressed environments characterized by variable wave action, sediment transport, turbulence, and water clarity.

Several studies have shown that the nearshore and surf zone beach rock outcrops seen along Florida's southeast coast are ephemeral in nature, being alternately covered and uncovered by shifting beach sand (Ginsburg, 1953; Gore *et al.*, 1978; Goldberg, 1982; Arthur V. Strock and Associates, Inc., 1983; Continental Shelf Associates, Inc., 1984, 1985, and 1987). Gilmore *et al.* (1981) and Continental Shelf Associates (1985, 1987) indicate that some larger outcrops may be more permanent environmental features.

Rock outcrops serve as a habitat for epibenthic species that can secure themselves to the hard substrate. Species present on nearshore rock outcrops must be extremely tolerant of fluctuation in the physical environment. This community is generally characterized by low profile encrusting and boring organisms. Outcrops located within the surf zone are well scoured by suspended sediments and wave action. This scouring prohibits settlement or subsequently kills the larvae of many sessile marine invertebrates (Jackson, 1979).

The exact composition of the community developed around such outcrops depends upon the physical features of the specific outcrop, its distance from shore, and its vertical relief. The width and vertical profiles of an outcrop formation determine its overall significance both as a biological resource and as a natural wave break. Larger outcrops normally show an increase in